Relations between Suicide and Traumatic Brain Injury, Psychiatric Diagnoses, and Relationship Problems, Active Component, U.S. Armed Forces, 2001-2009

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This retrospective case-control study of members of the active component of the U.S. Armed Forces compared those who died from suicide to controls matched by service, gender, race, age, date of entry into the active component, and years of service. The surveillance period was 2001 to 2009. The groups were compared with respect to numbers of deployments and documented diagnoses of traumatic brain injury (TBI), mood disorders, alcohol dependence, post-traumatic stress disorder (PTSD), partner relationship problems, and family circumstance problems. Cases and controls were similar regarding frequencies and types of TBIs and numbers of deployments. In multivariate analyses, increased odds of suicide were associated with mood disorders, partner relationship problems, and family circumstance problems, but not with mild TBI, alcohol dependence, or PTSD. A separate analysis revealed that psychiatric comorbidities increased odds of suicide. Limitations are discussed, including the possibility that some controls with mild TBIs may have died from suicide after their military service.

Traumatic brain injury (TBI) and suicide are concerning issues to the U.S. military. A recent review of responses to a screening questionnaire documented that 10 percent to 20 percent of a cohort of soldiers redeploying from Operations Iraqi and Enduring Freedom (OIF/OEF) reported experiences consistent with TBIs.[1]

Historically, military suicide rates have been lower than civilian rates. However, suicide rates among U.S. military members have increased recently and are now higher than rates among civilians with similar demographic characteristics.[2]

The Institute of Medicine (IOM) recently reviewed existing research on the potential association between TBI and suicide and noted that there is insufficient empirical evidence to determine whether such an association exists.[3] A large study of TBI patients in Denmark revealed that, relative to the general population, suicide risk was elevated among TBI patients across the range of severity (standardized mortality ratios of 3.0, 2.7, and 4.1 for mild, moderate, and severe TBIs, respectively).[4] However, several smaller studies in non-military populations did not find increased suicide risk among patients diagnosed with TBI.[5,6]

In a retrospective study of 22 psychiatric inpatients who were military veterans with histories of mild (n=1), moderate (n=11), and severe (n=10) TBIs, six had made suicide attempts.[7] A study of military service veterans who received care through the Veterans Healthcare Administration (VHA) from 2001-2006 indicated that veterans with histories of TBIs were at increased risk for suicide.[8] In sum, the extent to which TBI may increase suicide risk – in general or in military populations specifically – is unclear.

Studies in both non-military and military populations have noted associations between TBI, psychiatric diagnoses (including substance abuse), and suicide.[9-13] A recent U.S. Army epidemiological study found that suicide attempters were more likely than suicide completers to have diagnosed psychiatric problems.[14] Such findings suggest that suicide attempters and suicide completers may represent distinct, but overlapping, groups.[15]

Social adjustment in relation to TBI is another area of concern to the military. Of note in this regard, partner relationship problems appear to be associated with mild as well as severe TBIs;[16-18] in addition, partner relationship problems may relate to suicidal behaviors.[19-20] In response to such concerns, the 2010 Army Health Promotion Risk Reduction Suicide Prevention Report recommended research to clarify the relation between partner relationship problems and suicide.[21]

Finally, some evidence suggests that suicide risk may remain elevated for years after a traumatic brain injury.[12,22] Other research suggests that the risk period for suicide following TBI may be limited or non-existent.[4,14]

In summary, there are limited empirical data regarding TBI in relation to suicide mortality. Despite the high numbers of reported TBIs associated with deployments to Afghanistan and Iraq and the increased rate of suicide among U.S. military members, relationships between TBI and suicide among active duty military members have not been rigorously examined. This report documents 1) the prevalence and severity of TBIs among U.S. service members with and without completed suicides, 2) the latencies between TBI (by severity) and suicide, and 3) whether TBI increases the odds of suicide mortality after controlling for psychiatric diagnoses and partner relationship problems.

METHODS

For this report, a retrospective case–control study was conducted using records routinely provided to the Armed Forces Health Surveillance Center (AFHSC) and maintained in the Defense Medical Surveillance System (DMSS).[23]

The study population consisted of individuals who had served in the active component of the U.S. military between January

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14. ABSTRACT
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1, 2001 and December 31, 2009. Cases (n=1,764) were suicides that were identified through the Department of Defense (DoD) Medical Mortality Registry maintained by the Office of the Armed Forces Medical Examiner and were included in these analyses if the death had been officially declared a suicide of a service member in the active component. Controls (n=7,018) were randomly selected and matched in a 4:1 ratio to cases by service, gender, race (white, black, other), age within one year, entry into active component service within one year, and within one year of total active duty military service.

Dates and countries of deployment were used to determine the number of deployments to OEF/OIF among cases and controls.

Psychiatric diagnoses and behavioral health problems: Psychiatric diagnoses and partner relationship and family circumstance problems were ascertained from ICD-9-CM coded diagnoses that were reported on standardized records of inpatient and outpatient encounters in "fixed" (e.g., not deployed, at sea) military medical facilities and civilian facilities (contracted/purchased care through the Military Health System). **Table 1** provides the ICD-9-CM codes for each psychiatric condition and behavioral health problem entered as covariates in the conditional logistic regression model. For purposes of these analyses, these variables were defined as dichotomous (i.e., the presence of one of the ICD-9-CM codes of interest in any diagnostic position qualified an individual as having the condition or problem of interest).

TBI: The DoD's standard TBI surveillance case definition was used to ascertain TBI status and severity; in brief, this definition describes a TBI case as any TBI-related diagnosis in any diagnostic position during a single hospitalization or ambulatory visit in a U.S. military medical facility, or a civilian facility (i.e., MHS reimbursed care), or on a standardized record of an in-theater medical encounter of a deployed service member in the Theater Medical Data Store (TMDS). **Table 1** includes a list of ICD-9-CM diagnostic codes that are considered indicator diagnoses of TBI. If diagnoses of two or more TBIs fell within 30 days of each other, they were considered one TBI for analysis purposes.

TABLE 1. ICD-9-CM grouping of diagnostic categories and V-codes

Diagnostic category	ICD-9 codes
Alcohol dependence	303
Mood disorders	296.0, 296.2-296.7, 296.80, 296.89, 296.90, 300.4, 301.13, 311
PTSD	309.81
Partner relationship problems	V61.0, V61.1
Family circumstance problems	V61.2, V61.23, V61.24, V61.25, V61.29, V61.8, V61.9
Traumatic brain injury (TBI)	310.2,800.xx, 801.xx, 803.xx, 804.xx, 850.xx-854.xx, 950.1x-950.3x, 959.01, V15.5_1-9, V15.59_A-V15.59_F
mild TBI (subset of all TBI codes)	310.2, 800.00-800.02, 800.06, 800.09, 800.50, 800.52, 801.00, 801.01, 801.02, 801.06, 801.09, 801.50, 801.51, 801.52, 803.00-803.02, 803.06, 803.09, 803.50, 803.51, 803.52, 804.00, 804.01, 804.02, 804.06, 804.09, 804.50, 804.51, 804.52, 850.0, 805.1, 850.11, 850.9, 959.01, V15.52, V15.5_7, V15.5_C, V15.52_2, V15.52_2,V15.52_7, V15.52_C

Statistical analyses: Chi-square tests of homogeneity were performed to determine if the proportions of TBIs by severity were significantly different among cases and controls. A binary logit model with the Newton-Raphson ridge optimization technique was used to conduct conditional logistic regression analysis of matched paired data to model the relation between suicide and TBI, psychiatric comorbidities, and partner relationship and family circumstance problems.[24] Because there were insufficient cases of moderate and severe TBI, the relation was modeled only for mild TBI cases. Prior to conducting the conditional logistic regression analysis, a power analysis using a Pearson Chi-square Test for two proportions was performed to ensure that there was adequate power to detect an odds ratio ≥ 1.5. Results indicated that with the number of cases available, an odds ratio ≥ 1.3 with 80 percent power could be detected.

RESULTS

Ninety-six percent of the study subjects were males; 43.4 percent were Army, 20.1 percent were Air Force, 16.8 percent were Marine Corps, and 19.7 percent were Navy service members. Seventy-two percent of the study subjects were younger than 25 years old; 11.8 percent were 25-29, 13.5 percent were 30-39, and 2.4 percent were 40 or older **(Table 2)**.

Documented diagnoses of TBI

There were no statistically significant differences between suicide cases and matched controls regarding frequencies or

TABLE 2. Demographic and military characteristics of study suicide cases, active component, U.S. Armed Forces, 2001-2009

	Suicide	
	No.	%
Total	1,764	100
Service		
Army	766	43.4
Navy	348	19.7
Marine Corps	296	16.8
Air Force	354	20.1
Sex		
Male	1,696	96.1
Female	68	3.9
Age		
<25	1,275	72.3
25-29	209	11.8
30-39	238	13.5
40+	42	2.4

TABLE 3. TBI proportions by severity, gender, service, and age

TBI severity type (cases and controls)[a]						
	Severe	Moderate	Mild	Unclassified	None	Total
Cases	5 (0.3%)	25 (1.4%)	97 (5.5%)	2 (0.1%)	1,635 (92.7%)	1,764
Controls	11 (0.2%)	84 (1.2%)	323 (4.6%)	14 (0.2%)	6,586 (93.8%)	7,018
TBI severity type and gender (cases)						
	Severe	Moderate	Mild	Unclassified	None	Total
Male	5 (0.3%)	24 (1.4%)	91 (5.4%)	2 (0.1%)	1,574 (92.8%)	1,696
Female	0 (0%)	1 (1.5%)	6 (8.8%)	0 (0%)	61 (89.7%)	68
TBI by severity type and service (cases)						
	Severe	Moderate	Mild	Unclassified	None	Total
Army	1 (0.1%)	13 (1.7%)	52 (6.8%)	2 (0.3%)	698 (91.1%)	766
Navy	2 (0.6%)	5 (1.4%)	16 (4.6%)	0 (0%)	325 (93.4%)	348
Marine Corps	2 (0.7%)	3 (1.0%)	15 (5.1%)	0 (0%)	276 (93.2%)	296
Air Force	0 (0%)	4 (1.1%)	14 (4.0%)	0 (0%)	336 (95.0%)	354
TBI by severity type and age (cases)						
	Severe	Moderate	Mild	Unclassified	None	Total
<25	3 (0.2%)	14 (1.1%)	72 (5.7%)	2 (0.2%)	1,184 (92.9%)	1,275
25-29	1 (0.5%)	3 (1.4%)	15 (7.2%)	0 (0%)	190 (90.9%)	209
30-39	1 (0.4%)	7 (2.9%)	9 (3.8%)	0 (0%)	221 (92.9%)	238
40+	0 (0%)	1 (2.4%)	1 (2.4%)	0 (0%)	40 (95.2%)	42

[a]Cases, n=1,764; Controls, n=7,018

types of TBIs ($\chi 2=4.9$, p=not significant [ns]). Seven percent of cases and six percent of controls were diagnosed with TBIs. The distributions of TBIs among suicide cases according to TBI severity, gender, service, and age are presented in **Table 3**.

Time between TBI diagnoses and suicides

Time in days between traumatic brain injuries and suicides, by TBI severity, were: "mild" TBIs, n=97: mean=875 days, median=542 days; "moderate" TBIs, n=25: mean=1,122 days, median=682 days; and "severe" TBIs, n=5: mean=347 days, median=149 days. The times between TBIs and suicides across the TBI severity groups were not statistically significantly different (F [2, 124]=1.46, p = ns) **(data not shown)**.

Associations with suicide mortality

There were not statistically significant differences in the number of deployments of cases (mean=1.3, SD=.77) and controls (mean=1.3, SD=.80), F (1, 8,687)=.55, p =.46; as such, the number of deployments was not controlled in subsequent analyses. During multivariate analyses that accounted for the effects of mood disorders, alcohol dependence, PTSD, partner relationship problems, and mild TBI, mood disorders, partner relationship and family circumstance problems, but not mild TBI, were associated with increased odds of suicide mortality **(Table 4)**.

TABLE 4. Conditional logistic regression predicting suicide mortality

Effect	Odds ratio (95% confidence interval)
Mild TBI	1.1 (0.88 – 1.42)
Mood disorder	1.6 (1.37 – 1. 80)
Alcohol dependence	1.2 (0.92 – 1.45)
PTSD	1.1 (0.75 – 1.73)
Partner relationship problems	2.0 (1.51 – 2.63)
Family circumstance problems	2.0 (1.25 – 3.04)

In a separate analysis, psychiatric comorbidities were positively associated with increased odds of suicide mortality ($\chi 2=60.8$, p <0.01); this analysis documented a monotonic increase in the odds of suicide with increasing numbers of psychiatric comorbidities **(Table 5)**.

EDITORIAL COMMENT

The analyses conducted for this report do not confirm that mild TBIs increase suicide risk in active component members of the U.S. military. The finding is contrary to that of the only large population-based study that has examined suicide risk in relation to TBI across all levels of severity.[4] The different findings regarding the relationship between mild TBI and suicide risk may reflect important differences between the underlying populations and settings of the studies. For example, within civilian populations, TBIs, in general, appear to be associated with high risk behaviors (e.g., fighting, alcohol abuse) and psychopathology.[25-27] However, within military populations, TBIs may more commonly be associated with injuries that occur during training exercises or exposures to combat. This distinction may have meaningful implications. Among civilians, an association between mild TBI and suicide might be attributable to pre-existing personality characteristics and psychopathology that increase or mediate suicide risk. Conversely, mild TBI among service members may more often be attributable to unpredictable events associated with military training and combat. It is currently believed that mild TBI typically resolves within a few months; if so, absent pre-existing risk factors for suicide, mild TBI would not be expected to increase suicide risk as much among affected military members as civilians.

TABLE 5. Number of psychiatric comorbidities and odds of suicide mortality

Effect	Odds ratio (95% confidence interval)
1 vs. No psychiatric diagnosis	1.5 (1.3 – 1.7)
2 vs. No psychiatric diagnosis	1.9 (1.4 – 2.6)
3 vs. No psychiatric diagnosis	6.4 (2.7 – 15.0)

It is possible that some of the mild TBI cases considered in this analysis died by suicide after they left military service. Although the majority of mild TBIs typically resolve within a matter of months with proper treatment, it is estimated that up to 20 percent of such cases do not improve.[28-29] For individuals who do not improve, the persistence of their impairments may become more apparent over time. It is conceivable that such awareness in conjunction with other risk factors may increase suicide propensity, potentially accounting for longer latencies between mild TBIs and suicides – which, in some cases, may extend beyond the time of active military service.

This report assessed the experiences of actively serving military members; active service members are monitored medically and have ready access to resources that may be less accessible to military service veterans. In turn, suicide risk may increase after military members leave service. In light of the fact that most veterans do not seek care in the VHA, Brenner and colleagues suggested that veterans who receive care in the VHA may represent a particularly vulnerable group.[8] Additional research is needed to clarify relationships between TBI and suicide risk in various military-associated groups (e.g., active duty, veterans seeking care in the VHA, veterans not seeking care in the VHA).

Our findings regarding psychiatric problems in relation to suicide have clinical implications. The finding of increasing suicide risk with increasing psychiatric comorbidities is particularly noteworthy; for example, service members with three psychiatric diagnoses had six-times higher suicide risk than service members without psychiatric diagnoses. The findings suggest the need for tailored interventions, highlight the importance of thorough assessments across multiple domains of symptomatology, and are consistent with The Army Health Promotion Risk Reduction Suicide Prevention Report's call for research to help determine the "order of operations" for treatment of comorbid conditions such as PTSD, TBI, and depression.[21] Findings of this report also document that psychiatric problems increase risk for suicide, even though suicide attempters may have higher levels of psychiatric diagnoses and comorbidities than suicide completers. Additional research is needed to characterize similarities and differences in the natures and severities of psychiatric problems among suicide attempters, suicide completers, and non-suicidal controls.

The finding that partner relationship problems increase risk of suicide is consistent with descriptive data obtained through retrospective examinations of characteristics of military suicide decedents.[30] The finding underscores the importance of clinical assessments of partner relationship functioning and suggests targets for intervention and preventive efforts. For example, it may be prudent for clinicians to assess service members' intimate relationship functioning, even when not the presenting problem, and to focus efforts on facilitating competent resolution of partner relationship problems where such problems exist. Efforts of this kind may potentially avert suicide crises associated with partner relationship dysfunction and dissolution.

There are limitations to the analyses presented here that should be considered when interpreting the results. For example, the accuracy of psychiatric diagnoses is unknown. However, the only alternate source of population level psychiatric data is the self-report screening data obtained from post-deployment screenings. Given the limitations of self-report screens versus the care with which military clinicians are likely to assign psychiatric diagnoses, together with our theoretically consistent psychiatric findings, the ICD-9-CM codes used for this research are likely to reflect reasonable estimates of psychiatric problems. In addition, for this analysis, there were insufficient numbers of moderate and severe TBI cases to determine whether more severe TBIs were associated with increased suicide risk. Also, this analysis did not examine functional and occupational impairments associated with mild TBIs, which may be more closely tied to suicide risk than TBI per se. Furthermore, a longer follow-up period might have provided additional information about mild TBI as a suicide risk factor.

As a final note, these findings might be interpreted to suggest that the majority of service members are resilient to adverse effects potentially associated with mild TBIs. In this regard, it should be noted that the analyses conducted for this report examined only one outcome; there are a range of other potential problematic outcomes that were not assessed. Caution is warranted in interpreting the findings beyond the limited scope of the analyses. Clearly additional research is needed to provide a more complete understanding of relations among TBI and suicide among active military members.

In summary, continuous wartime operations in Afghanistan and Iraq over the past decade have been associated with increases in mild TBIs and suicides among U.S. military members. The analyses conducted for this report do not provide evidence of increased suicide risk after mild TBI in US military members. The findings are informative and potentially useful; however, further research regarding the natures, clinical effects, and natural courses of TBIs of various severities and their associations, if any, with suicide risk are indicated.

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